Fall Armyworm: Use of Virgin Female Traps To Detect Males and To Determine Seasonal Distribution

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Fall Armyworm: Use of Virgin Female Traps To Detect Males and To Determine Seasonal Distribution

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The distribution of lepidopterous insects is often studied in relation to insect suppression and eradication. The fall armyworm (*Spodoptera frugiperda* (J. E. Smith)) is of particular interest in this respect. It is one of the few insects known to disperse throughout the United States each year, only to be completely destroyed by cold weather except in small areas of southern Florida and southern Texas.[1] Its winter distribution in Florida is similar to that reported for the screw-worm (*Cochliomyia hominivorax* (Coquerel)),[2] and suggests the same possibility of eradication in the Southeastern States. Such a realization would be of great economic importance to agriculture because of extensive losses suffered each year in the production of grasses, corn, and numerous other crops.

This is a report of research on a trapping system for detecting populations and seasonal distribution of the fall armyworm, with females as a lure. Such traps can provide preliminary data for suppression or eradication programs. The distribution of this insect is also given.

Testing and Constructing an Effective Trap

Various traps baited with females were tested for their effectiveness in capturing fall armyworm males. Escape from the trap was prevented by using Stikem, a sticky material. Designs of some of the traps tested are shown in figure 1.

Factors considered in addition to trapping efficiency were ease of operation, cost, durability, and function of the trap. Function is particularly important. As an example, traps *D*, *F*, and *H* (fig. 1) retained insects after capture so that accurate counts could be made. Whereas traps *A*, *C*, *E*, and *G* caught them, but counts were lower because birds removed the insects from traps *A* and *G* and captured insects escaped from traps *C* and *E*. Those that escaped were killed as they became Stikem laden. The open-board trap *B* was unsatisfactory. Trap *D*, constructed of 10-inch piepans, caught more fall armyworm males than any other trap, but it required extensive maintenance because the Stikem was affected by the weather. This trap also caught numerous other species in random movement. Traps *F* and *H*, constructed of cardboard, were effective and may eventually prove superior if sufficient traps are required to justify special construction.

Considering all factors, a trap similar to the Steiner trap (fig. 2) proved to be the most effective and practical. All data presented here are based on using this trap.

It was constructed by cutting holes 2¼ inches in diameter in each end of a quart plastic container, 3$^{11}/_{16}$ inches in diameter by 5½ inches deep. A screw lid was fastened on one end. Other necessary modifications were

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[1] Luginbill, Philip. the fall armyworm. U.S. Dept. Agr. Tech. Bul. 34, 89 pp. 1928.

[2] Bruce, W. G. screwworm survey of the southeastern states in 1943. Jour. Econ. Ent. 37: 687–689. 1943.

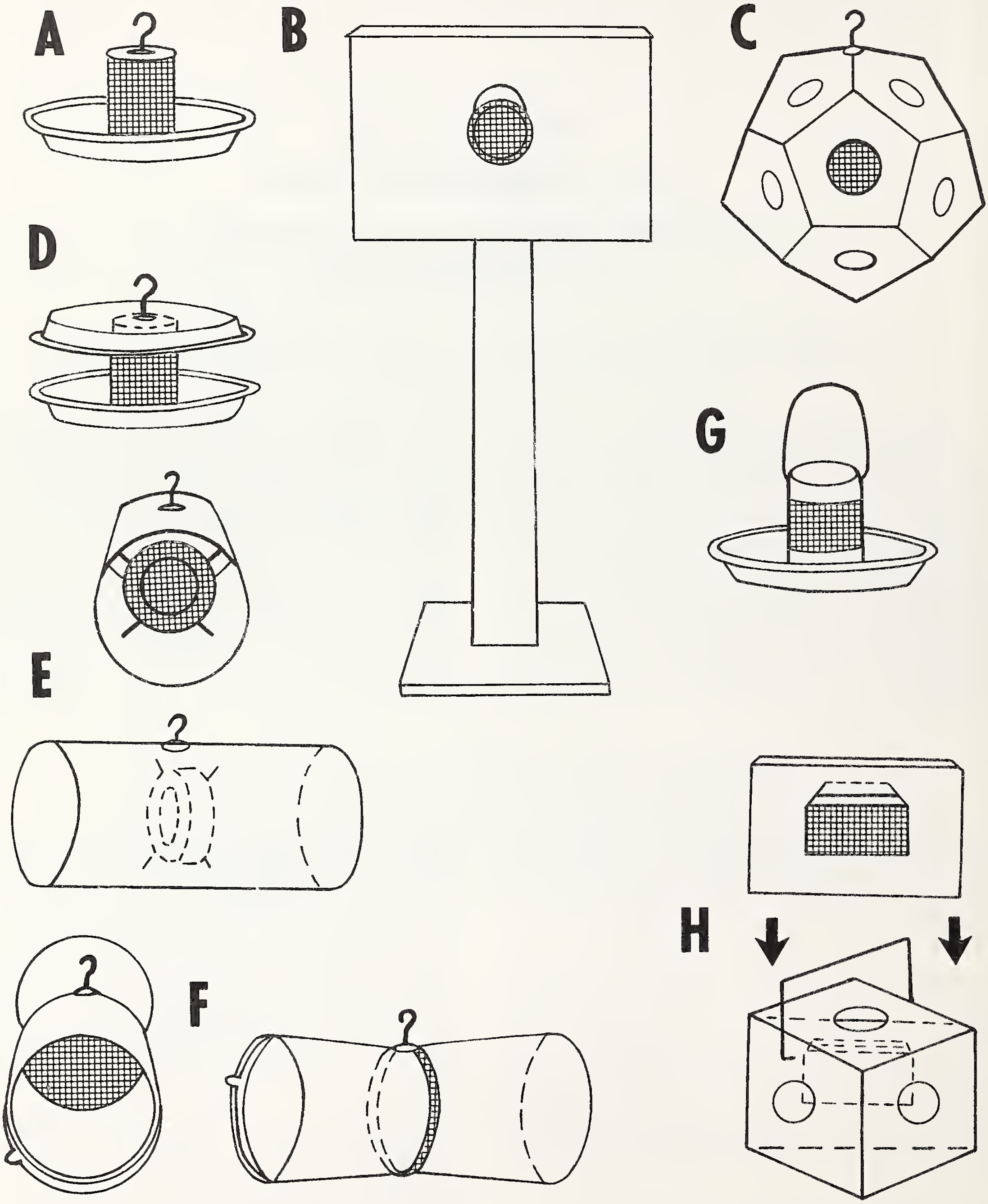

FIGURE 1.—Designs of traps tested for effectiveness in capturing fall armyworm males.

adding a hook (paper clips) for field use and applying a thin layer of Stikem on the inside wall of the container. Living females were inserted into this trap by using another plastic container, 2 inches in diameter by $1\frac{7}{16}$ inches deep. Both ends of this smaller container were replaced with screen wire (fig. 2). It was secured in the trap with paper clips. Plastic cages may be purchased for about $0.35 per unit.[3]

Trapping Experiments, 1966

Experiments were conducted to determine the most effective use of the trap to capture fall armyworm males in a large field of bermudagrass and bahiagrass. In a randomized complete block design, each trap was separated from the others by at least 50 feet. An analysis of variance and Duncan's multiple range test were applied to the data.

All experiments were conducted from July 1 through October 1966, which includes the period of peak moth abundance in the Tifton, Ga., area. Comparisons of the males captured in the various experiments should be avoided for several reasons. All experiments were conducted at different times; consequently, the numbers of natural males available for capture varied. Traps were baited with one to nine females and captures were recorded after 1 to 4 days depending on the particular experiment. Environmental conditions during the extended trapping period affected the capture of males. In general, on heavy overcast or rainy nights the greatest numbers were caught.

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FIGURE 2.—Trap used to capture fall armyworm males.

Trap Height

The first experiment was made to determine whether trap height affected male capture. Traps were suspended at various heights above the ground. They were baited with five virgin females per trap. The experiment was replicated eight times, with the following captures recorded after 2 nights:

Height above ground (feet)	*Mean catch* [1]
1	7.6 ab
3	16.1 c
6	10.8 b
9	4.6 a

[1] Values followed by same letter here and in succeeding tabulations do not differ significantly at 5-percent level.

Since captures at the 3-foot level were significantly greater than those at other heights, all subsequent experiments were conducted at this height.

Size of Trap Openings

To determine the most efficient size of the trap openings, five diameters were evaluated. Each trap was baited with two virgin females. The experiment was replicated eight times, with captures recorded after 1 night as follows:

Diameter of trap opening (inches)	*Mean catch*
0.75	0.13 a
1.50	1.75 b
2.25	5.25 c
2.75	4.75 c
3.50	4.75 c

[3] May be obtained from Tri-State Plastic Molding Co., Box 337, Henderson, Ky. 42420.

Statistical analysis of the data indicates that the size of the opening significantly affects the capture. Traps with openings of 0.75 and 1.50 inches caught fewer males than traps with larger openings. Based on these data, a 2.25-inch opening was used in subsequent testing.

Females per Trap

The effect of different numbers of virgin females per trap on male capture was tested. The experiment was replicated eight times, with the following captures recorded after 1 night:

Females per trap (number)	*Mean catch*
1	2.5 a
3	3.2 ab
6	4.3 bc
9	5.3 c

These data indicate that the number of captured males increases as the number of virgin females per trap increases. However, the increase in catch was not proportional to the increase in number of females.

Female Age

The effect of female age on attracting males was tested. Virgin females of various ages were placed singly in traps. The experiment was replicated 20 times, with captures recorded after 1 night as follows:

Female age (days)	*Mean catch*
1	2.9 d
2	7.4 e
3	3.0 d
4	1.8 c
5	1.2 b
6	.3 a

Two-day-old females were significantly more attractive to males. Females 1 and 3 days old were equally attractive and both were significantly more attractive than those over 3 days old. Attractiveness was greatly reduced after 3 days of age.

Virgin and Mated Females

The ability of virgin and mated females to compete for the natural male population was determined by placing both virgin and mated females in the field. To obtain these insects for testing, laboratory-reared females emerging the same night were placed singly with males, whereas others were held without males. After confinement for 1 night, the males were dissected to determine whether the females had mated.[4] The females were then placed individually in traps in a replicated experiment. Twelve traps for each female condition were used, with captures recorded after 2 days as follows:

Female condition	*Mean catch*
Virgin	5
Mated	0

Sixty males were captured in the 12 virgin female traps and none in the mated female traps.

These data should not be interpreted to mean that females are not attractive after one mating, but merely that in these experiments the mated females were unable to compete with the virgin females for males in the natural population. Apparently when traps were 50 feet apart, males in the test area were able to detect and preferred the virgin females. The attraction of males for mated females has been demonstrated in the laboratory when up to seven matings per female were reported.[5]

Fed and Unfed Females

The effect of fed and unfed females on male catch was determined. The fed females were given a beer solution in a small 2-gram vial stoppered with absorbent cotton, which acted as a wick. Three females were placed in each trap. The experiment was replicated 16 times, with captures recorded after 4 days as follows:

Female condition	*Mean catch*
Fed	19.9
Unfed	14.3

Fed females caught significantly more males than the unfed ones. Apparently fed females lived longer and had a longer exposure to the male population. After the fourth day, 15 percent of the fed moths were dead, whereas 55 percent of the unfed moths were dead.

Mating Status of Natural Male Population

The mating status of captured males from the natural population, based on several days' catch, was determined.[6] The findings are shown in table 1.

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[4] SNOW, J. W., and CARLYSLE, T. C. A CHARACTERISTIC INDICATING THE MATING STATUS OF MALE FALL ARMYWORM MOTHS. Amer. Ent. Soc. Ann. 60: 1071–1074. 1967.

[5] YOUNG, J. R., SNOW, J. W., and SPARKS, A. N. MATING OF UNTREATED AND TEPA-CHEMOSTERILIZED FALL ARMYWORM MOTHS. Jour. Econ. Ent. 61: 657–661. 1968.

[6] See footnote 4.

TABLE 1.—*Mating status of captured males from fall armyworm natural population, based on 4 days' catch, 1966*

Date	Males captured	Males mated
	Number	*Percent*
July 20	34	56
July 22	21	67
July 28	162	54
Aug. 11	60	62
Total or average	277	60

On each of the 4 nights mated males represented a sizable percentage of the males attracted to females. These data indicate that males in the field commonly mate more than once. Unfortunately the male characteristic does not determine how many times a male mated, but merely whether it has mated. Records of mating of the fall armyworm female in the field are not available in the literature.

Value of Trap for Surveys

To determine the trap's value for insect surveys, a series of traps was placed at 1-mile intervals along a busy highway (Interstate 75) during August 1966. Traps were put at two locations to determine whether traffic would interfere with male capture. Half of them were fastened to highway markers on the shoulder of the road (fig. 3) and the others were located on a protective fence, which was from 25 to 150 feet from the edge of the highway depending on the terrain. All traps were baited with fed virgin females and placed 3 feet above the ground. The results of 1 night's capture are shown in table 2.

Females at both locations were able to attract and capture males. For survey use, both locations would be adequate to determine the presence of the fall armyworm in the area.

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FIGURE 3.—Typical terrain along Interstate 75 between Tifton and Cordele, Ga., showing road markers (*A*) and protective fence (*B*).

Variable catches at a particular location may have been due to the local terrain, but there was no consistent increase or decrease in catch based on the distance of the trap from the road. This is important from a survey standpoint, because traps near the road are easier to maintain. The areas surrounding the traps varied from row crops and pasture to wooded areas and swamps. No conclusions can be drawn as to which locations were more favorable. Attempts to predict capture based on location have been unsuccessful.

TABLE 2.—*Fall armyworm males captured in traps placed at 1-mile intervals next to busy highway and on protective fence 25–150 feet from highway, 1966*

Trap location No.	Males trapped	
	Next to road	On fence
	Number	*Number*
1	([1])	33
2	17	5
3	6	4
4	12	([2])
5	11	16
6	3	4
7	1	2
8	24	18
9	13	2
10	7	1
11	7	24
12	6	22
13	19	4
14	9	6
15	12	16
16	9	24
17	19	18
18	16	24
19	6	1
20	16	3
21	12	20
22	16	15
23	4	0
24	11	0
25	9	12
26	15	0
27	12	3
28	0	10
29	10	0
30	3	0
31	14	2
32	15	0
33	2	12
34	0	0
35	3	0
36	11	42
37	2	21
Total	352	364

[1] Trap removed.
[2] Escaped.

Trapping Experiment, 1966–68

A series of 16 traps was operated at Tifton, Ga., from December 1966 through January 1968. The locations were selected to represent general terrain typical of the area, and once established the locations were not changed.

Four virgin females were used as bait in each trap. The females were changed and the insects collected twice weekly. The total males captured and the mean low temperatures for each weekly period are shown in table 3. These temperatures were calculated by averaging the lowest temperatures recorded each night during a week.

TABLE 3.—*Fall armyworm males captured and mean low temperatures for each week at Tifton, Ga., 1966–68*

Date	Males captured	Mean low temperature	Date	Males captured	Mean low temperature
1966	*Number*	*° F.*		*Number*	*° F.*
Dec. 5–10	12	47	*1967*—Con.		
Dec. 12–17	7	35	July 3–8	----------	68
Dec. 19–24	0	39	July 10–15	135	67
Dec. 26–31	1	37	July 17–22	129	67
1967			July 24–29	183	70
Jan. 2–7	0	42	July 31–Aug. 5	174	69
Jan. 9–14	0	36	Aug. 7–12	----------	71
Jan. 16–21	0	34	Aug. 14–19	----------	65
Jan. 23–28	0	48	Aug. 21–26	264	70
Jan. 30–Feb. 4	0	42	Aug. 28–Sept. 2	234	67
Feb. 6–11	0	34	Sept. 4–9	223	65
Feb. 13–18	0	43	Sept. 11–16	248	59
Feb. 20–25	0	36	Sept. 18–23	67	62
Feb. 27–Mar. 4	0	37	Sept. 25–30	6	55
Mar. 6–11	0	49	Oct. 2–7	13	53
Mar. 13–18	0	47	Oct. 9–14	22	54
Mar. 20–25	0	43	Oct. 16–21	21	48
Mar. 27–Apr. 1	0	58	Oct. 23–28	23	49
Apr. 3–8	0	58	Oct. 30–Nov. 4	28	52
Apr. 10–15	0	61	Nov. 6–11	1	32
Apr. 17–22	0	60	Nov. 13–18	0	44
Apr. 24–29	2	56	Nov. 20–25	8	48
May 1–6	24	58	Nov. 27–Dec. 2	7	47
May 8–13	26	57	Dec. 4–9	5	50
May 15–20	([1])	57	Dec. 11–16	19	51
May 22–27	19	59	Dec. 18–23	2	58
May 29–June 3	----------	64	Dec. 25–30	0	40
June 5–10	34	64	*1968*		
June 12–17	88	67	Jan. 1–6	0	43
June 19–24	97	69	Jan. 8–13	0	33
June 26–July 1	148	70	Jan. 15–20	0	29
			Jan. 22–27	0	35

[1] Traps not operated.

Since the trap locations varied in their conduciveness to capture, weekly fluctuations should be considered rather than total male captures. Males were in the area when trapping was started in December 1966, but no captures occurred from January to late April. Based on these data, Tifton was not in the area of continuous generations. The first males were detected during the week of April 24–29, and adults were captured from then through December 1967. The decline in population both years coincides with freezing temperatures. The peak numbers of males were collected during August and September, which is the time of principal economic damage to late-planted corn, peanuts, and various grasses.

Distribution

Since Luginbill's original work[7] in 1928 on occurrence and distribution of the fall armyworm, more recent larval and adult location reports have been published in the Cooperative Insect Survey Report for 17 years. These reports have been used to plot the data in figure 4.

In figure 4 the total number of reports is shown in the States with many records, whereas individual reports are indicated in the other States. Only seven States are without specific records of the species within their borders. Apparently lack of reports rather than absence of fall armyworms in these States caused this void. The insect's range seems to be over all the continental States, at least in some years. It has been found more frequently in the Southern States, where the most extensive damage is reported. However, the number of reports from a State does not necessarily indicate heavier populations but merely frequent reporting.

In figure 5 the annual northward progress of the insect is shown. The actual dates of the reports for figure 4 were used to calculate the progress shown in figure 5, which is an estimate of the real situation; extensive surveys will be needed to pinpoint the species movement.

This illustration verifies Luginbill's report[7] that consistent continuous populations within the United States are confined to small areas of southern Florida and southern Texas. However, during mild winters this insect may survive in most of Florida and a larger area of Texas, as well as in southern Louisiana. Fluctuation in survival of the fall armyworm occurs between years and within a year depending on the temperature.

Continuous generations may occur in the gulf coast area of Mississippi and Alabama, but many reports from there fail to indicate this fact. From available evidence, the fall armyworm appears in these areas in April or May when moths are migrating from Florida or Louisiana.

Larval reports for every month of the year indicate that the species survives in the Salt River Valley area of Arizona in some years. Continuous generations in this area would greatly affect the time of activity in the adjacent States.

The northward advance of moths (fig. 5) indicates a much more rapid movement than Luginbill reported.[7] Adults and larvae in some years may be found in the more northern States by late July or August. No reasonable estimate of the distance covered by a single adult can be made; certainly prevailing winds and temperatures affect its dispersal.

Discussion

The direction of movement of the fall armyworm from the areas of continuous generation is not known. Whether eliminating this species in the limited winter area of Florida would free the Southeastern United States of populations, as occurred with the screw-worm, can only be speculated. Based on the data given here, virgin female traps can be used to detect fall armyworm populations in an area and their seasonal distribution. Captures from survey traps can be used to estimate population trends.

[7] See footnote 1.

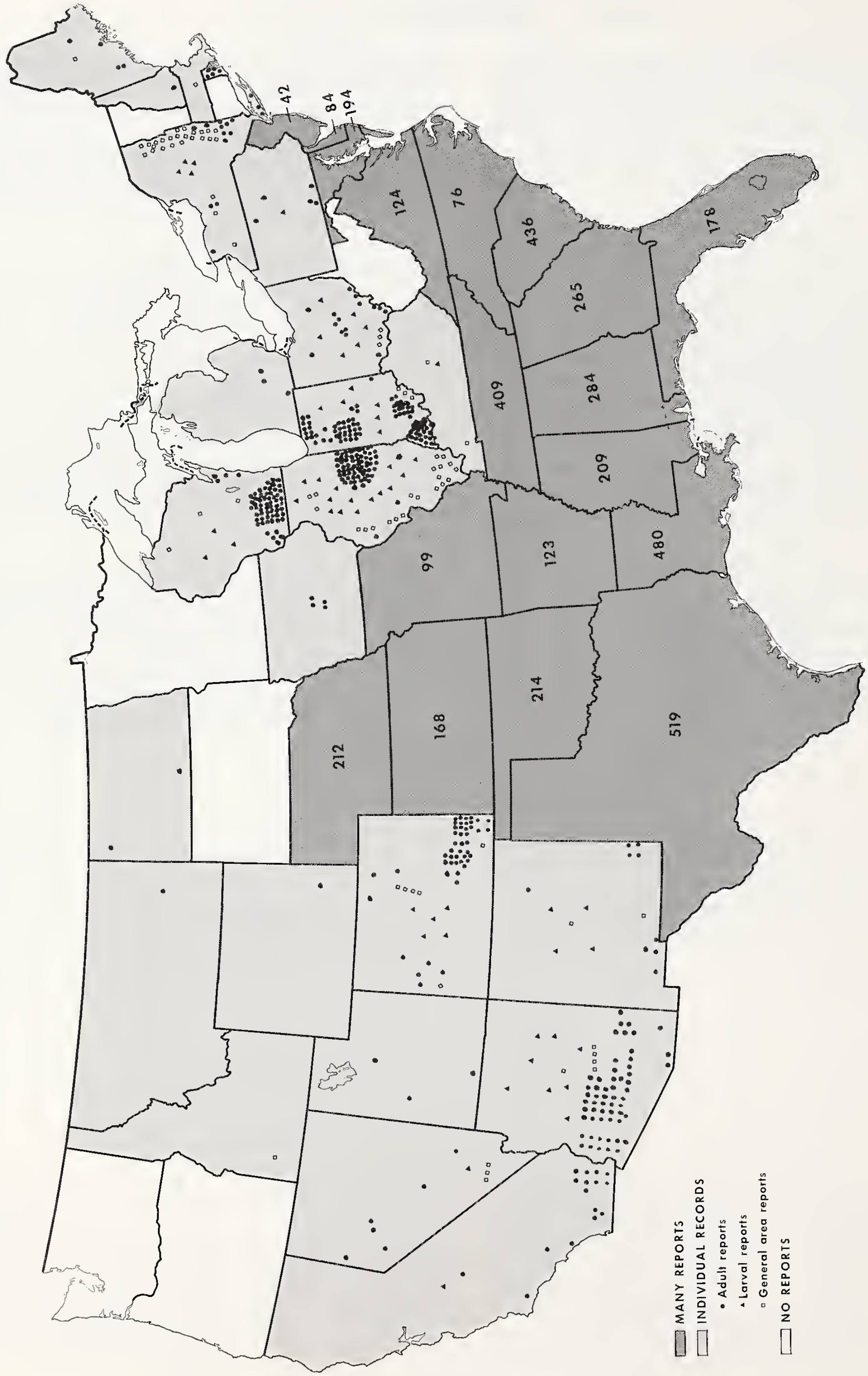

FIGURE 4.—Areas of United States infested by fall armyworm in some years. [Data from Cooperative Insect Survey Report.]

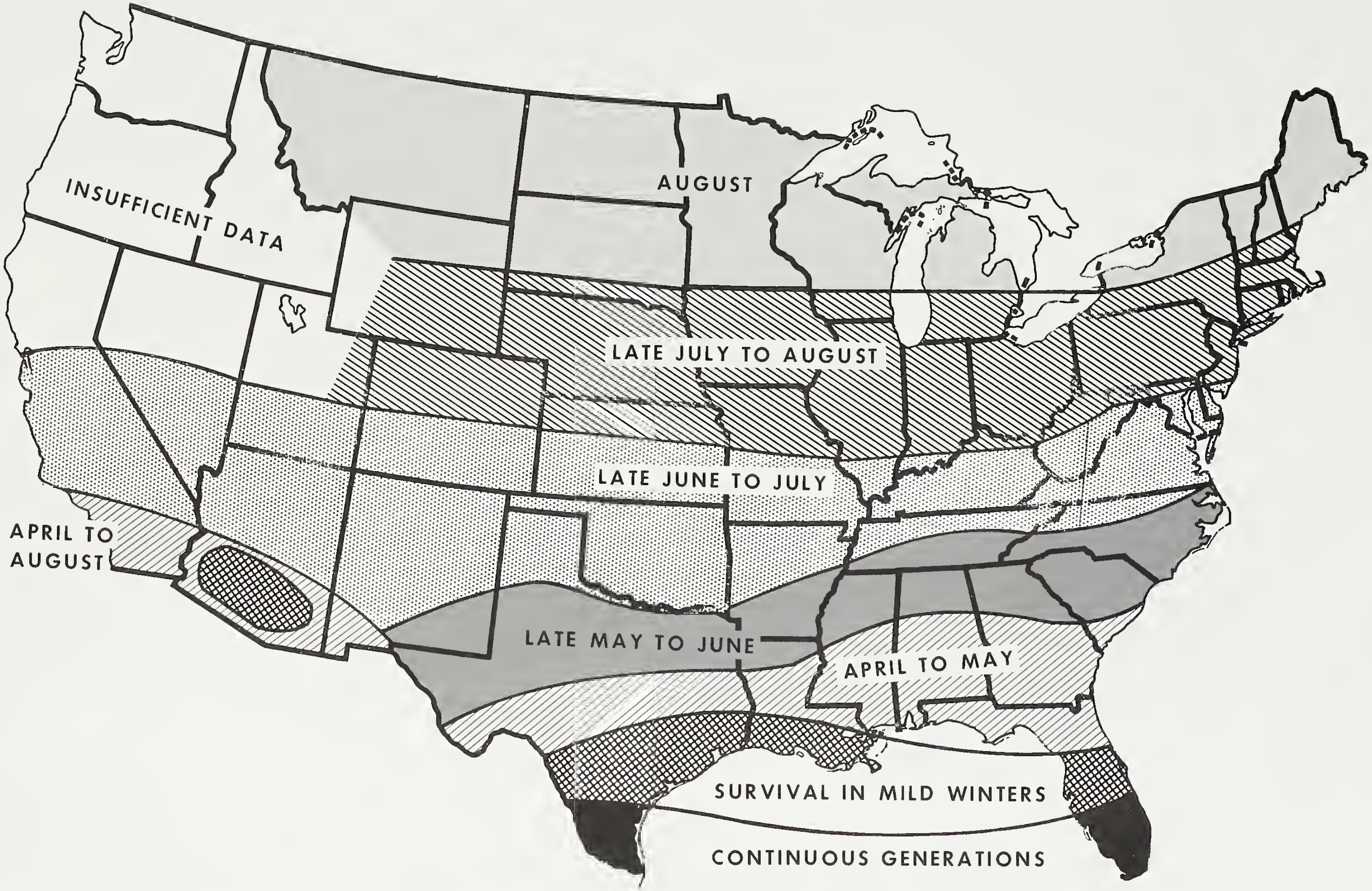

FIGURE 5.—Annual northward progress of fall armyworm and areas of continuous generations and of survival in mild winters in United States. [Data from Cooperative Insect Survey Report.]

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